# FIELD MEASUREMENT OF BOTTOM-BOUNDARY-LAYER AND SEDIMENT-TRANSPORT PROCESSES IN SUPPORT OF THE STRATAFORM SHELF DYNAMICS AND PLUME STUDIES

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## LONG-TERM GOAL

The global objective of the Virginia Institute of Marine Science involvement in the *STRATAFORM* program is to improve understanding of the spatially and temporally varying mechanisms that suspend, transport, and deposit sediment on the continental shelf in the vicinity of the mouth of the Eel River specifically and generally on continental shelves that are accumulating fine sediment.

## SCIENTIFIC OBJECTIVES

Specific objectives of efforts to date have been: a) to characterize the spatial and temporal variability of bed roughness; b) to obtain estimates of time-varying bed stresses at two sites on two across-shelf transects of the mid shelf including one transect in close proximity to the Eel River plume source; c) to evaluate sediment resuspension and flux in response to observed stresses at multiple sites; d) to examine the effects of abundant under-consolidated fine sediment on bottom-boundary-layer processes; and e) to examine bottom-boundary-layer processes and transport mechanisms associated sediment-laden flood plumes from Eel River.

## APPROACH

Our approach involved field observations of bed micromorphology (roughness), benthic flow, bed stress, and suspended-sediment flux on the Northern California continental shelf north of the Eel River mouth. Over the late fall and winter of 1995 to 1996, we obtained regional measurements of bottom roughness at the *STRATAFORM* shelf sites via side-scan sonar surveys and made more detailed, localized measurements using plan-view and sediment-water interface-profiling cameras. We obtained data from two fully-instrumented bottom-boundary-layer tripods on the “S” line at depths of 60 m and 70 m, beginning on 5 January and continuing through the month of February 1996 during which time two high energy events occurred. The tripods were deployed on “G” line at depths of 30 m and 60 m over the period 21 November, 1996-27 January 1997, period that included a major flood event.

The two tripods deployed on the “S” line in January and February of 1996 were configured to collect benthic-boundary-layer profiles of velocity and suspended-sediment concentration. They supported arrays of electromagnetic current meter sensors within the near-bed log layer, pressure gage, optical backscatter (OBS) sensors for suspended sediment profiling. The two tripods deployed by VIMS on the “G” line in winter of 1996/1997 were similar in configuration to those used on the “S” line but also supported an Acoustic Doppler Velocimeter (ADV), and an upward looking acoustic-Doppler water column velocity profiler (ADP).

## WORK COMPLETED

From the first deployment (Jan.-Feb. 1996), we retrieved roughly 2 months (at 8 bursts a day) of data. Most of the analyses of this data set are now completed. We retrieved more than 2 months (at 6 bursts a day) of pressure, velocity, and suspended sediment data from the 60 m tripod on “G” line during the second deployment (Nov.1996-Jan.1997) . As of October17, 1997, apparent instrument burial has prevented

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recovery of the “G” 30 m tripod. All of the data from both deployments are now available for use by other STRATAFORM investigators. The summary data are available on 3.5 diskettes and at the VIMS STRATAFORM website: http://www.vims.edu/physical/strataf/strataform.htm. The complete data sets including measurements within bursts are available on CD-ROM.

Data analyses, interpretations and reporting have taken place progressively over the period of the grant. Data reports (Wright et al., 1996; Hepworth et al., 1997) including data summaries on diskettes were prepared and distributed to interested STRATAFORM participants as soon as initial analyses and data quality assessments were completed. Some initial results from the first field experiment were reported in a special issue of *Oceanography* by Wiberg et al. (1996). A more detailed and substantive paper on the VIMS results is now in press awaiting publication in a special issue of *Marine Geology* (Wright et al., in press).

**RESULTS**

Analyses and interpretations from the first field experiment are reported in a manuscript now in press (Wright et al. in press) and those results are summarized as follows: Biogenic roughness with ~ 2 cm relief prevailed at both the 60 m and 70 m sites on “S” line in late 1995. Bottom-boundary-layer tripods were deployed on the 60 m and 70 m isobaths over the period 5 January to 7 March 1996 during which time two high energy events occurred. Skin-friction shear stresses were subcritical under "average" conditions but appreciably exceeded the threshold for sediment suspension during storms. During those high-energy events, near-bed suspended sediment concentrations reached 2 g/l at 60 m (15 cm above bed) and 1g/l at 70 m (27 cm above bed) and suspended-sediment-induced stratification significantly affected bed stress estimates. At those times, increases in current shear were accompanied by increases in suspended-sediment-concentration gradients causing the gradient Richardson number within the log layer to remain near the critical value of ¼. This suggests suppression of turbulence by sediment induced stratification.

The abundance of under-consolidated fine sediment on the shelf to the north of the Eel River mouth presumably allows increases in stress to be accompanied by progressive increases in suspended-sediment concentration within the log layer to maintain the critical balance. This contrasts to situations where bed armoring limits the total amount of fine sediment in suspension. Applications of a wave-current boundary-layer model with stratification effects included reduces estimates of current friction velocities, $u_{*c}$ by about 24% relative to results from fitting the von Karman-Prantdl equation without stratification. The model suggests that the total wave-current friction velocity, $u_{*cw}$, reached 3.0 cm/s at 70m and 3.5 cm/s at 60 m. Depth-integrated across-shelf suspended-sediment fluxes were offshore at the 60 m isobath and near zero to weakly onshore at the 70 m isobath during high-energy periods, implying flux convergence. This is consistent with the conclusions of other STRATAFORM investigators that rapid long-term accumulation of mud is occurring on the mid shelf. A general implication is that shelf settings that are rapidly accumulating fine sediment in the presence of frequent agitation by waves, as is the case on the mid shelf off the Eel River mouth, may favor continual production of stable stratification by sediment resuspension until an “equilibrium” is reached and further resuspension is inhibited.

**IMPACT/APPLICATION**

Measurements of near-bottom processes at different depths on the shelf provide insights into the mechanisms responsible for along-shelf and across-shelf transport, the sources and nature of across-shelf variations in hydraulic roughness, and the causes and steepnesses of the across-shelf gradients in sediment flux that may contribute to sediment deposition. Our results are expected to lead to modified models for transport of highly concentrated fine sediment over soft, easily eroded beds.

**TRANSITIONS**

Our data on bed stresses and resulting sediment resuspension have been made available to modelers and other *STRATAFORM* investigators and are expected to be used to verify bottom boundary layer and sediment transport models.

**RELATED PROJECTS**

1. Biological Mediation of Bottom Boundary Layer Processes and Sediment Transport in Estuaries. Office of Naval Research (Harbor Processes).
2. Suspension and cross-shelf transport of larvae. National Science Foundation (co-op).
3. Physical and biological mechanisms development and evolution of sedimentary structure. Naval Research Laboratory (Coastal Benthic Boundary Layer).

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